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Indian Standard

PLANNING AND DESIGN OF FISH PASS — GUIDELINES

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Barrages and Weirs Sectional Committee, RVD 20

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Barrages and Weirs Sectional Committee had been approved by the River Valley Division Council.

A fish pass is a device provided in barrages, rapids or similar type of obstacles in rivers to facilitate the movement of fish from upstream to downstream and vice-versa.

When a diversion structure is constructed across the river, the passage of the fish is obstructed. Hence for the protection of fish, especially of migratory types, it would be necessary to construct suitable fish pass as a component of the diversion structure. Aspects relating to their location, investigation and data to be collected, type of fish passes, design requirements, etc, are included in this standard.

Indian Standard

PLANNING AND DESIGN OF FISH PASS — GUIDELINES

1 SCOPE

This standard covers guidelines for location, investigation, type and design of fish pass.

2 LOCATION

2.1 The fish pass should be provided near the deep channel through which they always move about. Its location should be readily found by the migrating fish as otherwise the fish may never enter the fishway.

2.2 The entrance and exit of the fish pass should be away from the range of heavy overfall of water from the diversion structure. The fish pass is usually located near the divide wall of the structure between the sluice bays and spillway bays, since water would always be available near the divide wall.

3 INVESTIGATIONS AND DATA REQUIRED

3.1 For planning and designing an effective fish pass, certain data should be collected after thorough investigations and the data analyzed. Some important investigations are given in **3.1.1** to **3.2.2**.

3.1.1 Type of fish, their characteristics, habits, instincts and environmental behaviour.

3.1.2 Place of spawning, whether at particular spots or anywhere.

3.1.3 If anadromous in nature, location map of the river/streams showing the migratory route and spawning grounds.

3.1.4 Timing of upstream and downstream migration, nature of river flows, turbidity and temperature of water during these periods.

3.1.5 Maximum number of fish passing per hour during peak migration period.

3.1.6 Requirement of water per fish when confined to keep it in normal condition.

3.1.7 Nature of migration, whether in groups or in line.

3.1.8 The number of fish passing upstream of the proposed structure for the previous periods say for a period of 30 years.

3.1.9 Commercial value of the fisheries they contribute in order to work out economics of having a fish pass or not.

3.1.10 The normal swimming speed of fish, its darting speed and preference for swimming or jumping.

3.1.11 The stimuli of fish, whether it is attracted by large volume of water or greater velocity.

3.1.12 The normal time that fish takes from downstream to spawning grounds and the delay which it is capable of withstanding without any detrimental effect on its biological functions.

3.1.13 The size of downstream migrants.

3.1.14 The nature of spawning ground and the river conditions at the time of spawning, namely, velocity, depth, turbidity and temperature of water.

3.2 Hydraulics

3.2.1 River velocity and river discharge are two most important hydraulic data which are to be known correctly. Other hydraulic data such as location of points of turbulence, upwelling and intensity of surge are to be correcitly recorded. These data can then be related to biological observations of the behaviour of fish in the marginal areas in order to ensure that the fishway is located in the best location.

3.2.2 By plotting the hydrograph of river discharge and fish migration period, it is possible to determine the range of discharge likely to be available during the period of migration and the water surface profiles for each river bank corresponding to this range may be used in the design of the fish pass.

4 TYPES OF FISH PASS

The fish pass can be of two types, namely, fish locks and fish ladders. The fish ladders can be further subdivided into five types as (i) inclined chute type, (ii) pool and weir type, (iii) pool and orifice type, (iv) pool and jet type, and (v) Denil type.

4.1 Fish Lock

The operation of fish lock (*see* Fig. 1) is similar to that of navigation lock. A group of fish is admitted into the lock at a time and transferred either to upstream or downstream as the case may be. The lock is generally located next to the divide wall.

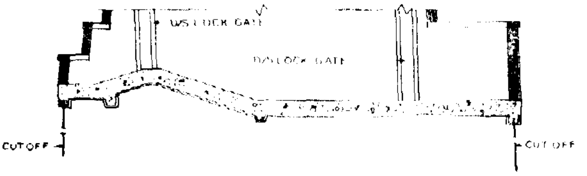

FIG. 1 TYPICAL DETAILS OF FISH LOCK

4.2 Fish Ladder

4.2.1 *Inclined Chute Type*

The inclined chute types have checks or baffles which are so arranged that the discharging water takes a zig-zag course, being driven from side to side. These are of two types namely, paired obstacle and alternate obstacle fish pass.

4.2.1.1 *Paired obstacles fish pass*

The paired obstacles fish pass (*see* Fig. 2) consists of a sloping pairs of obstacles spaced along the channel at intervals equal to about the width of the channel and a straight free passage between them. The free passage is considerably restricted and one-half to five-eighths of the channel width being taken up by the obstacles. The floor in the free passage is usually flat, although small bottom obstacles may be used. The wide spacing of the pair of obstacles along the channel gives the fish pass the hydraulic function of a pool and jet type fish pass, but since the pools are divided by the central flow, they do not afford much of a resting place except to the smaller fish. When the Denil type is compared with the paired obstacles fish pass, the ratio of preference is 5 : 1 in favour of Denil type. Cat-fish does not prefer the paired obstacles fish pass.

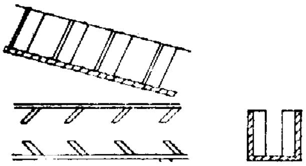

FIG. 2 PAIRED OBSTACLE TYPE FISH PASS

4.2.1.2 *Alternate obstacle fish pass*

Alternate obstacle fish pass (*see* Fig. 3) consists in general of a straight rectangular channel with obstacles or baffles placed alternatively along the sides producing a jet deflection in the horizontal plane. The flow is confined to zig-zag path which is much longer than the fish pass. This type of fish pass is not quite satisfactory. A type of this fish pass with a reasonable slope of say 1 in 4 is shown in Fig. 3.

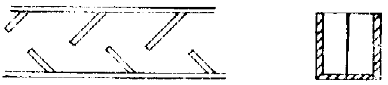

FIG. 3 ALTERNATE OBSTACLE TYPE FISH PASS

4.2.2 *Pool and Weir Type*

The fish ladder of this type (*see* Fig. 4) usually consists of a series of pools with small drops in water surface at the cross walls. Drops in water surface are generally about 0·3 metre, but could be as great as 0·6 m at short ladders where only a few jumps are necessary. Long ladders are often provided with intermediate rest pools. The migratory fish jump from one step to the other.

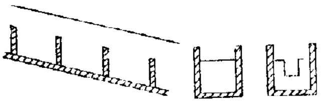

FIG. 4 POOL AND WEIR TYPE FISH PASS

4.2.3 *Pool and Orifice Type*

Sometimes the entire flow between the pools is passed through a submerged orifice, and the fish ascend from pool to pool through the orifices. These are of two types: (a) Coil type, and (b) Submerged orifice type (*see* Fig. 5 and 6).

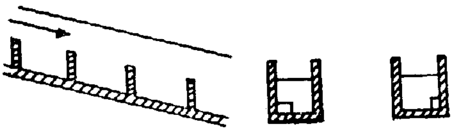

FIG. 5 COIL TYPE FISH PASS

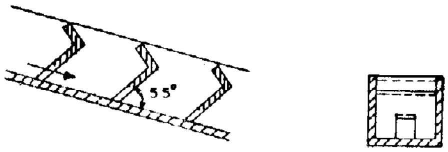

FIG. 6 POOL AND SUBMERGED ORIFICE TYPE FISH PASS

When the obstacles have submerged orifices, the fish generally prefer to use them, thus avoiding exposure.

4.2.4 *Pool and Jet Type*

This is similar to the pool and orifice type except that the orifice extends over the full height of the baffle in the form of a vertical slot rather than a submerged orifice.

In negotiating an overfall the fish usually swim up the falling jet.

4.2.5 *Denil Fish Pass*

The Denil or channel type of fish pass consists of a straight channel with closely spaced baffles set at an angle with the axis of the channel. The energy of the water flowing down the steep flume is dissipated by the closely spaced baffles or vanes on the sides and bottom, thereby causing part of the flow to turn back on itself. The velocity of the water turned by the vanes meets the velocity of the main flow in the central part of the fish pass, which results in reduction in velocity. It is equally effective as alternate obstacle fish pass (*see* **4.2.1.2**).

4.2.5.1 The Denil fish pass shown in Fig. 7 is a simple arrangement. It is a channel having bottom baffles formed from oblique and perpendicular parts. The system has proved quite efficient. The velocities in the channel are extremely moderate. This simple symmetrical fish pass can be used for shallow depths.

4.2.5.2 Modification of the Denil fish pass having parallel baffles at the sides, placed at an angle with the side walls and the bottom shown in Fig. 8 has proved to be very efficient.

4.2.5.3 Another modified Denil fish pass, shown in Fig. 9 has been evolved out from a series of laboratory experiments. It has been seen that this fish pass is not affected by head and tail water conditions as long as the fish can enter the fish pass and sufficient water is flowing. Strong overtopping does not reduce its effectiveness.

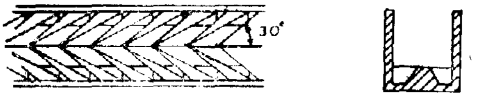

FIG. 7 DENIL TYPE (SMALL) FISH PASS (ALTERNATIVE-I)

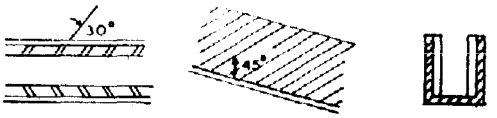

FIG. 8 DENIL TYPE (SMALL) FISH PASS (ALTERNATIVE-II)

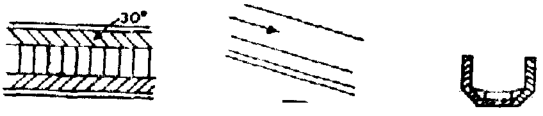

FIG. 9 DENIL TYPE (SMALL) FISH PASS (ALTERNATIVE-III)

5 SELECTION OF TYPE

5.1 The selection of the type of fish pass, either a fish lock or fish ladder (any sub type) depends on many considerations including economy, but the prime consideration is the suitability or attraction to the migratory fish. The fisheries department has to be invariably consulted before the structure is selected and planned.

5.2 Hydraulic model studies may be got conducted for selection of the appropriate type of fish pass and to formulate its design.

5.3 The Denil type of fish pass which incorporate the ideas of energy dissipation is generally adaptable to any particular set of local conditions and requirements. Alternative types also should be considered and compared for economy and attraction to fish.

5.4 Paired obstacle fish pass adapts itself to a considerable range of head water elevation.

5.5 Where the majority of fish is of the cat-fish variety, Denil type may be advantageous. An alternative obstacle type may be preferable for quill black fish variety.

5.6 Typical details of fish pass are shown in Fig. 10.

6 DESIGN REQUIREMENTS

6.1 The dimension of the fish pass, supply of water and grade would have to be suitably adjusted to reduce the turbulence in the compartments to the point where the fish variety would not become fatigued. The following points may serve as guidelines in a satisfactory design of a fish pass.

6.1.1 The entrance should be well submerged at all stages of water when the fish are seeking ascent through it.

6.1.2 If the flow from a fish pass is small compared to flow in the river, an auxiliary water supply may be required to increase the velocity of flow out of the fish entrance for the purpose of attracting the fish more readily.

6.1.3 *Vertical Slot Baffle Type*

Ascent by fish is possible at any depth of the fish pass. Depending on rate of migration, the pool capacity should be adequately provided to reduce fish stress. Approximately 0·113 m^3 of space is required for fish movement of major carp of 150 mm length. The slot width should be adjusted in relation to the sizes of fish. A minimum 300 mm slot width is regarded as sufficient for free entry of big fish. The larger the slot width, the larger the pool size necessary to cushion and dissipate the energy of the increased rate of flow passing through the slot.

6.1.4 *Pool Capacity*

The pool capacity may be determined by using the following expression:

$$V = \frac{Cv}{60\,r}$$

where

V = pool capacity in m^3,

v = volume required per fish in m^3,

C = fish pass capacity in numbers of fish per hour, and

r = rate of ascent in number of pools per minute.

The size of fish pass depends on the available volume of water, the number of fish expected to use the fish pass, size, speed and kind of species which will use the fish pass.

6.1.5 The rate of migration through fish pass may be considered in the range of 2 to 5 minutes per 300 mm rise of fish pass, for bigger sizes of riverine fishes.

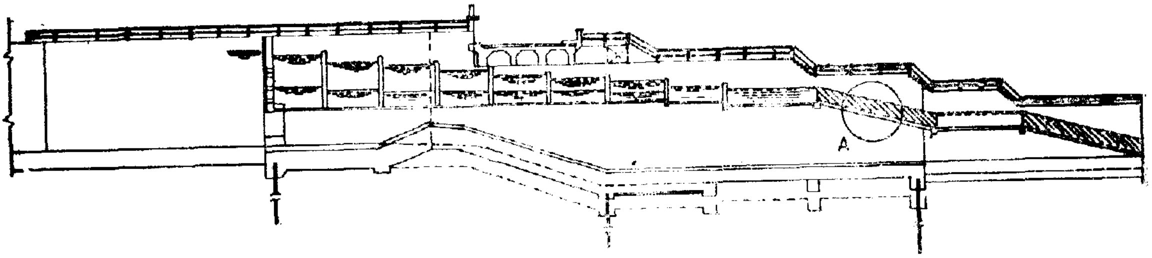

FIG. 10 TYPICAL SECTIONAL ELEVATION OF A FISH PASS IN A BARRAGE

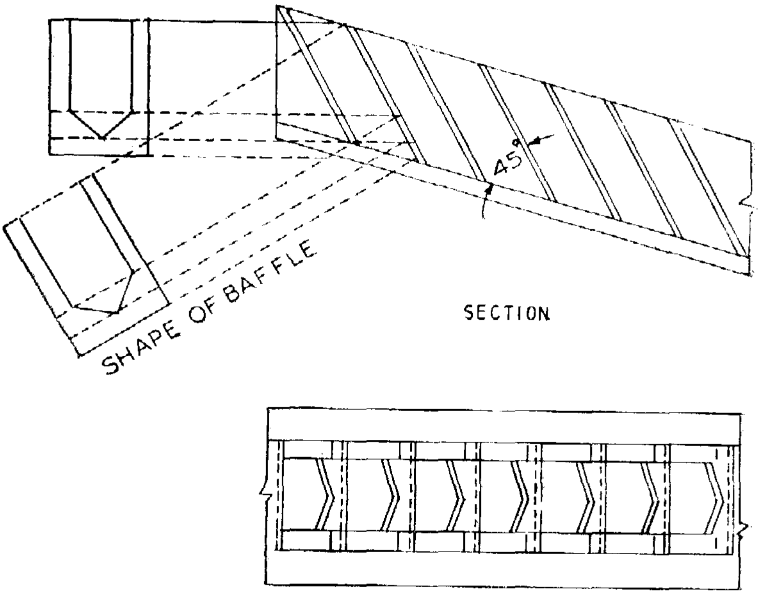

FIG. 10A DETAIL OF 'A'

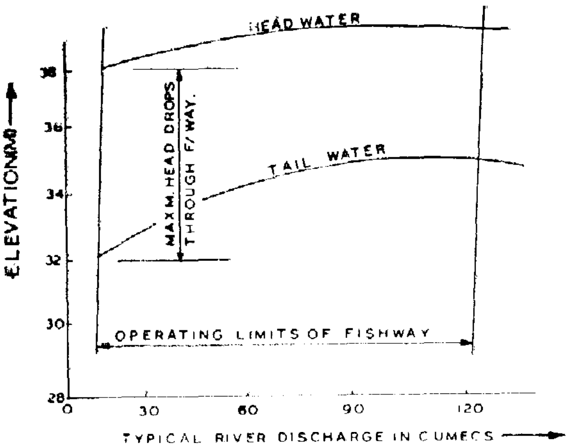

FIG. 11 TYPICAL STAGE DISCHARGE CURVE

6.1.6 *Head Difference between Pool*

The head loss per pool may be varied to decrease flow and check turbulence. For smaller pools (1 800 mm × 2 400 mm or so) the head per baffle should be 200 cm, while for larger pools (3 000 mm × 3 600 mm) elevation difference between pools may be kept 300 mm.

6.1.7 *Fish Pass Gradient*

The fish pass gradient should preferably be 1 : 10 so as to ensure a flow velocity not exceeding 1 800 mm per sec in any portion of fish pass.

General practice is to provide average velocity of 600 to 900 mm/sec in each pool.

6.1.8 *Spacing of Baffles*

To check the number of baffles required, it is desirable to draw correctly a set of headwater and tailwater curves (*see* Fig. 11). To do this, the elevations of the water surface at the upstream end of the fish pass and the downstream end are determined from the water surface profiles at various rates of discharge (*see* Fig. 12). The maximum distance between these two curves will guide in deciding the number of baffles required to be placed in the fish pass to overcome this head.

6.1.9 Pool depths usually vary from about 1 m at small ladders to about 2 m at large ladders.

6.1.10 At weirs on small streams, pools may be from 1·25 m to 2·5 m wide and 2 to 3 m long. At weirs on large rivers, pools may be 6 m to 12 m wide, but never more than 6 m long.

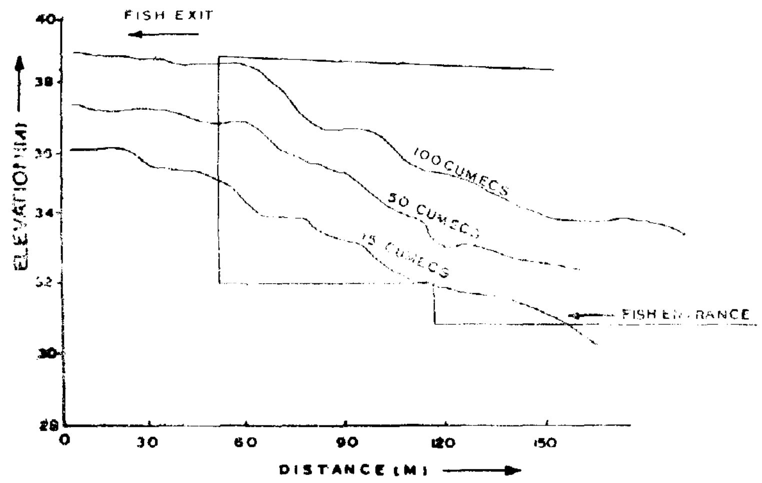

FIG. 12 TYPICAL WATER SURFACE PROFILE

6.1.11 *Length of Fish Pass in Barrages*

The length of the fish pass should be considered from the point of entrance downstream to a place above the barrage where relatively calm water with low velocity is available, which will not sweep away the fish passing through the fish pass.

7 REGULATION

7.1 The upper end of the fish pass should be provided with regulating arrangements so that the quantity of fish admitted can be controlled. Otherwise, the compartments would be unduly flooded during high water periods and insufficient supplies during low water periods.

7.2 Automatic regulation may be provided where the variation of water level is not too great, by the provision of a series of compartments with apertures through the bottom of the dividing partitions, the dimensions of the apertures being reduced in each successive partition commencing at the inlet.

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